Rec'd PCT/PTO 28 NOV 1997

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(REV 10-96)

U.S. DEPARTMENT OF COMMERCE PATENT AND TRADEMARK OFFICE

TRANSMITTAL LETTER TO THE UNITED STATES DESIGNATED/ELECTED OFFICE (DO/EO/US) CONCERNING A FILING UNDER 35 U.S.C. 371

ATTORNEY'S DOCKET NUMBER: 70554-2 /8137

U.S. APPLICATION NO. (If known, see 37 CFR 1.5): 08/973210

INTERNATIONAL APPLICATION NO.	INTERNATIONAL FILING DATE	PRIORITY DATE CLAIMED
PCT/SE97/00875	27 May 1997	29 May 1996

TITLE OF INVENTION: TRANSFORMER/REACTOR

APPLICANT(S) FOR DO/EO/US: LEIJON, Mats

Applicant herewith submits to the United States Designated/Elected Office (DO/EO/US) the following items and other information:

1. [X] This is a **FIRST** submission of items concerning a filing under 35 U.S.C. 371.
2. [ ] This is a **SECOND** or **SUBSEQUENT** submission of items concerning a filing under 35 U.S.C. 371.
3. [ ] This express request to begin national examination procedures (35 U.S.C. 371(f)) at any time rather than delay examination until the expiration of the applicable time limit set in 35 U.S.C. 371(b) and PCT Articles 22 and 39(1).
4. [ ] A proper Demand for International Preliminary Examination was made by the 19th month from the earliest claimed priority date.
5. [ ] A copy of the International Application as filed (35 U.S.C. 371(c)(2))
   a. [ ] is transmitted herewith (required only if not transmitted by the International Bureau).
   b. [ ] has been transmitted by the International Bureau.
   c. [ ] is not required, as the application was filed in the United States Receiving Office (RO/US).
6. [ ] A translation of the International Application into English (35 U.S.C. 371(c)(2)).
7. [ ] Amendments to the claims of the International Application under PCT Article 19 (35 U.S.C. 371(c)(3))
   a. [ ] are transmitted herewith (required only if not transmitted by the International Bureau).
   b. [ ] have been transmitted by the International Bureau.
   c. [ ] have not been made; however, the time limit for making such amendments has NOT expired.
   d. [ ] have not been made and will not be made.
8. [ ] A translation of the amendments to the claims under PCT Article 19 (35 U.S.C. 371(c)(3)).
9. [ ] An oath or declaration of the inventor(s) (35 U.S.C. 371(c)(4)).
10. [ ] A translation of the annexes to the International Preliminary Examination Report under PCT Article 36 (35 U.S.C. 371(c)(5)).

Items 11. to 16. below concern document(s) or information included:

11. [X] An Information Disclosure Statement under 37 CFR 1.97 and 1.98.
12. [ ] An assignment document for recording. A separate cover sheet in compliance with 37 CFR 3.28 and 3.31 is included.
13. [X] A FIRST preliminary amendment.
    [ ] A SECOND or SUBSEQUENT preliminary amendment.
14. [ ] A substitute specification.
15. [ ] A change of power of attorney and/or address letter.
16. [X] Other items or information:
    Request
    International Application as filed

U.S. APPLICATION NO. (if known, see 37 CFR 1.5)	INTERNATIONAL APPLICATION NO. PCT/SE97/00875	ATTORNEY'S DOCKET NUMBER 70554-2/8137

17. [X] The following fees are submitted:

	CALCULATIONS	PTO USE ONLY
BASIC NATIONAL FEE (37 CFR 1.492 (a) (1) - (5)):		
Search Report has been prepared by the EPO or JPO $930.00		
International preliminary examination fee paid to USPTO (37 CFR 1.482) $720.00		
No international preliminary examination fee paid to USPTO (37 CFR 1.482) but international search fee paid to USPTO (37 CFR 1.445(a)(2)) $790.00		
Neither international preliminary examination fee (37 CFR 1.482) nor international search fee (37 CFR 1.445(a)(2)) paid to USPTO $1070.00		
International preliminary examination fee paid to USPTO (37 CFR 1.482) and all claims satisfied provisions of PCT Article 33(2)-(4) $98.00		
ENTER APPROPRIATE BASIC FEE AMOUNT =	$ 1,070	
Surcharge of $130.00 for furnishing the oath or declaration later than [ ] 20 [ ] 30 months from the earliest claimed priority date (37 CFR 1.492(e)).	$	

CLAIMS	NUMBER FILED	NUMBER EXTRA	RATE		
Total claims	39 - 20 =	19	X $22.00	$ 418	
Independent claims	3 - 3 =	0	X $82.00	$ --	
MULTIPLE DEPENDENT CLAIM(S) (if applicable)			+ $270.00	$ -	

TOTAL OF ABOVE CALCULATIONS =	$ 1,488	
Reduction of 1/2 for filing by small entity, if applicable. Verified Small Entity Statement must also by filed (Note 37 CFR 1.9, 1.27, 1.28).	$	
SUBTOTAL =	$ 1,488	
Processing fee of $130.00 for furnishing the English translation later than [ ] 20 [ ] 30 months from the earliest claimed priority date (37 CFR 1.492(f)).	$	
TOTAL NATIONAL FEE =	$ 1,488	
Fee for recording the enclosed assignment (37 CFR 1.21(h)). The assignment must be accompanied by an appropriate cover sheet (37 CFR 3.28, 3.31). $40.00 per property	$	
TOTAL FEES ENCLOSED =	$ 1,488	
	Amount to be: refunded	$
	charged	$

a. [X] A check in the amount of $ 1,488.00 to cover the above fees is enclosed.

b. [ ] Please charge my Deposit Account No. ______________ in the amount of $______________ to cover the above fees. A duplicate copy of this sheet is enclosed.

c. [X] The Commissioner is hereby authorized to charge any additional fees which may be required, or credit any overpayment to Deposit Account No. 23-0576. A duplicate copy of this sheet is enclosed.

NOTE: Where an appropriate time limit under 37 CFR 1.494 or 1.495 has not been met, a petition to revive (37 CFR 1.137(a) or (b)) must be filed and granted to restore the application to pending status.

SEND ALL CORRESPONDENCE TO

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SIGNATURE:

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NAME

25,505
REGISTRATION NUMBER

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70554-2/8137

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Application of:	PATENT
Mats LEIJON	Group: Unknown
New appln. based on PCT/SE97/00875	Examiner: Unknown
Serial No.: To be assigned	
Filed: On even date	**ATTN: BOX PCT**
TRANSFORMER/REACTOR	

* * * * * *

PRELIMINARY AMENDMENT

Washington, D.C.

Assistant Commissioner for Patents
Washington, D.C. 20231

NOV 28 1997

Sir:

Concurrently with the U.S. national filing of this application, please amend the present application as follows:

IN THE CLAIMS:

Amend claims 1-25 as follows:

Claim 1. (Amended) A power transformer/reactor comprising at least one winding, [characterized in that the winding/windings comprise one or more] including at least one current-carrying conductor[, that around each conductor [(4)] there is arranged]; a first layer [(6)] with semiconducting properties surrounding the

conductor; [, that around the first layer there is arranged] a solid insulating layer surrounding the first layer; [part (7), and that around the insulating part there is arranged] a second layer [(8)] with semiconducting properties surrounding the insulating layer.

Claim 2 (Amended), line 2, delete "characterized in that" and insert --wherein--; delete "(6)".

Claim 3. (Amended) A power transformer/reactor according to [one or more of the preceding claims, characterized in that] claim 1, wherein the second layer [(8) is arranged in such a way that it essentially constitutes] comprises an equipotential surface surrounding the conductor[/conductors].

Claim 4. (Amended) A power transformer/reactor according to [one or more of the preceding claims, characterized in that] claim 1, wherein the second layer [(8)] is [connected] connectable to earth potential.

Claim 5. (Amended) A power transformer/reactor according to [one or more of the preceding claims, characterized in that] claim 1, wherein the first and second semiconducting layers [(6,8)] and the insulating layer [part (7)] have substantially the same coefficient of thermal expansion such that, upon a thermal movement in the winding, defects, cracks or the like do not arise in the boundary layer between the semiconducting layers and the insulating part.

Claim 6. (Amended) A power transformer/reactor according to claim 1, wherein the first and second layers have respective contact surfaces secured to

corresponding surfaces of the adjacent insulating layer [one or more of the preceding claims, characterized in that] each of the semiconducting layers [(6,8)] is secured to the adjacent solid insulating layer [part (7)] along essentially the whole [adjoining] contact surface.

Claim 7. (Amended) A power transformer/reactor according to [one or more of the preceding claims, characterized in that] claim 1, wherein the at least one winding[/windings is/are designed in the form of] comprises a flexible cable.

Claim 8. (Amended) A power transformer/reactor according to claim 7, [characterized in that] wherein the cable is manufactured with a conductor area which is between about 30 and 3000 mm^2 and with an outer cable diameter which is between about 20 and 250 mm.

Claim 9. (Amended) A power transformer/reactor according to [one or more of the preceding claims, characterized in that] claim 1, wherein at least one of the first and second layers and the solid insulation [(7) are formed by] comprise polymeric materials.

Claim 10. (Amended) A power transformer/reactor according to [one or more of the preceding claims, characterized in that] claim 1, wherein the winding is free of partial discharge [first layer (6) and/or the second layer (8) are formed by polymeric materials].

Claim 11. (Amended) A power transformer/reactor according to [one or more of the preceding claims, characterized in that] claim 1, wherein the solid insulation [(7) has been obtained by] comprises an extrusion.

Claim 12. (Amended) A power transformer/reactor according to claim 1, wherein [one or more of the preceding claims, characterized in that] the current-carrying conductor [(4)] comprises a first plurality [number] of strands[, said strands] being insulated from each other and a second plurality of strands being [except a few strands that are] uninsulated in order to secure electric contact with the first semiconducting layer [(6)].

Claim 13. (Amended) A power transformer/reactor according to claim 1, wherein the cable is substantially void free [one or more of the preceding claims, characterized in that at least one of the strands of the conductor (4) is uninsulated and arranged in such a way that electrical contact is achieved with the inner semiconducting layer].

Claim 14. (Amended) A power transformer/reactor according to [one or more of the preceding claims, characterized in that] claim 1, wherein the power transformer/reactor comprises a core [consisting] of magnetic material.

Claim 15. (Amended) A power transformer/reactor according to [one or more of the preceding claims, characterized in that] claim 1, wherein the power transformer/reactor comprises an iron core [consisting of] including core limbs and yokes.

Claim 16. (Amended) A power transformer/reactor according to claim 1[-13, characterized in that] wherein the power transformer/reactor is air wound and formed without an iron core [(air-wound)].

Claim 17. (Amended) A power transformer/reactor according to claim 1, further comprising at least two galvanically separated concentrically wound windings [according to any preceding claim, characterized in that the windings are concentrically wound].

Claim 18. (Amended) A power transformer/reactor according to [one or more of the preceding claims, characterized in that] claim 1, wherein the power transformer/reactor is [connected to two or more] connectable to a plurality of voltage levels.

Claim 19. (Amended) A power transformer/reactor according to [one or more of the preceding claims, characterized in that] claim 1, wherein the windings include terminals in the form of [the high and/or low-voltage winding are jointed to a power cable and/or made similar to] power cable [termination(s)] terminations.

Claim 20. (Amended) A power transformer/reactor according to [one or more of the preceding claims, characterized in that] claim 1, wherein the insulation layer is formed of a solid electrical insulation, substantially all of the electrical insulation in the transformer/reactor is enclosed between the conductor [(4)] and the second layer [(8)] of the windings [and which insulation is in the form of solid insulation].

Claim 21. (Amended) A power transformer/reactor according to claim 1, wherein the cable includes means for sustaining a high voltage at transmission levels including at least one of greater than 10kV, 36kV, 75.5kV, 400 kV and 800 kV [one or more of the preceding claims, characterized in that the winding thereof is designed for high voltage, suitably in excess of 10 kV, in particular in excess of 36 kV, and preferably more than 72,5 kV and up to very high transmission voltages, such as 400 kV to 800 kV or higher].

Claim 22. (Amended) A power transformer/reactor according to [one or more of the preceding claims, characterized in] claim 1, wherein the transformer/reactor is designed for a power range in excess of at least 0.5 MVA[, preferably in excess of] and 30 MVA.

Claim 23. (Amended) [The cooling of a] A power transformer/reactor according to [one or more of the preceding claims, characterized in that] claim 1, wherein the power transformer/reactor includes cooling means comprising at least one of [is cooled with] liquid and[/or] gas [on] at earth potential.

Claim 24. (Amended) A method for electric field control in a power transformer/reactor comprising forming a magnetic field generating circuit having at least one winding with at least one electrical conductor [and] an insulation layer and at least one outer layer [present] externally thereof, [characterized in that] wherein the insulation is formed by a solid insulation material and [that an outer layer is provided externally of the insulation,] said outer layer being connected to ground or

otherwise a relatively low potential and having an electrical conductivity [being] higher than the conductivity of the insulation but lower than the conductivity of the electrical conductor so as to [function for equalization of] equalize potential and cause the electrical field to be substantially enclosed in the winding internally of the outer layer.

Claim 25. (Amended) A method [in production of a power transformer/reactor] according to claim 24, wherein [one ore more of the preceding claims, characterized in that] a flexible cable is used as a winding and [that] the winding of the cable to form the winding[/windings] of the transformer/reactor is assembled on-site.

Please add new claims 26-38 as follows:

--26. A method according to claim 24, further comprising connecting the outer layer to near ground potential.

27. A high voltage electric machine comprising at least one of a transformer and reactor including a winding in the form of a cable including at least one current-carrying conductor and a magnetically permeable, electric field confining cover surrounding the conductor, said cable forming at least one uninterrupted turn in the corresponding winding of said machine.

28. The machine of claim 27, wherein the cover comprises an insulating layer surrounding the conductor and an outer layer surrounding the insulating layer, said outer layer having a conductivity sufficient to establish an equipotential surface around the conductor.

29. The machine of claim 27, wherein the cover comprises an inner layer surrounding the conductor and being in electrical contact therewith; an insulating layer surrounding the inner layer and an outer layer surrounding the insulating layer.

30. The machine of claim 29, wherein the inner and outer layers have semiconducting properties.

31. The machine of claim 27, wherein the cover is formed of a plurality of layers including an insulating layer and wherein said plurality of layers are substantially void free.

32. The machine of claim 27, wherein the cover is in electrical contact with the conductor.

33. The machine of claim 27, wherein the layers of the cover have substantially the same temperature coefficient of expansion.

34. The machine of claim 27, wherein the machine is operable at 100% overload for two hours.

35. The machine of claim 27, wherein the cable is operable free of sensible end winding loss.

36. The machine of claim 27, wherein the winding is operable free of partial discharge and field control.

37. The machine of claim 27, wherein the winding comprises multiple uninterrupted turns.

38. The machine of claim 27, wherein the cable comprises a transmission

line.

39. The machine of claim 27, wherein the cable is flexible.--

If any multiple dependencies exist in the claims, it is respectfully requested that such dependencies be removed.

REMARKS

By this Preliminary Amendment the original claims have been amended to better conform the claims with U.S. practice and to remove multiple dependencies therefrom. New claims set forth the invention in a different scope.

Respectfully submitted,

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Transformer, reactor

TECHNICAL FIELD

The present invention relates to a power transformer/reactor.

For all transmission and distribution of electric energy, transformers are used and their task is to allow exchange of electric energy between two or more electric systems. A transformer is a classical electrical product which has existed, both theoretically and practically, for more than 100 years. This is manifestly clear from the German patent specification DE 40414 from 1885. Transformers are available in all power ranges from the VA up to the 1000 MVA range. With respect to the voltage range, there is a spectrum up to the highest transmission voltages which are being used today.

A transformer belongs to an electrical product group which, regarding the fundamental mode of operation, is relatively easy to understand. For the energy transfer between the electric systems, electromagnetic induction is utilized. There are a great number of textbooks and articles which more or less theoretically and practically describe the theory, calculations, manufacture, use, service life, etc., of the transformer. In addition, there are a large number of patent documents relating to successively improved embodiments of the different parts of a transformer, such as, for example, windings, core, tank, accessories, cooling, etc.

The invention relates to a transformer belonging to the so-called power transformers with a rated power ranging from a few hundred kVA up to more than 1000 MVA with a rated voltage ranging from 3-4 kV and up to very high transmission voltages, 400 kV to 800 kV or higher.

The inventive concept which is the basis of the present invention is also applicable to reactors. The following

description of the background art, however, mainly relates to power transformers. As is well-known, reactors may be designed as single-phase and three-phase reactors. As regards insulation and cooling there are, in principle, the same embodiments as for transformers. Thus, air-insulated and oil-insulated, self-cooled, oil cooled, etc., reactors are available. Although reactors have one winding (per phase) and may be designed both with and without an iron core, the description of the background art is to a large extent relevant to reactors.

BACKGROUND ART, THE PROBLEMS

In order to place a power transformer/reactor according to the invention in its proper context and hence be able to describe a new approach in accordance with the invention in addition to the advantages afforded by the invention with respect to the prior art, a relatively complete description of a power transformer as it is currently designed will first be given below as well in addition to the limitations and problems which exist when it comes to calculations, design, insulation, earthing, manufacture, use, testing, transport, etc., of these transformers.

With respect to the above-mentioned, there is a comprehensive literature describing transformers in general, and more particularly, power transformers. Reference may be made, for example, to the following:

<u>The J & P Transformer Book, A Practical Technology of the Power Transformer</u>, by A. C. Franklin and D. P. Franklin, published by Butterworths, edition 11, 1990.

Regarding the internal electrical insulation of windings, etc., the following can be mentioned:

Transformerboard, Die Verwendung von Transformerboard in Grossleistungstransformatoren by H. P. Moser, published by H. Weidman AG, CH-8640 Rapperswil.

From a purely general point of view, the primary task of a power transformer is to allow exchange of electric energy between two or more electrical systems of, usually, different voltages with the same frequency.

A conventional power transformer comprises a transformer core, in the following referred to as a core, often of laminated oriented sheet, usually of silicon steel. The core comprises a number of core limbs, connected by yokes which together form one or more core windows. Transformers with such a core are often referred to as core transformers. Around the core limbs there are a number of windings which are normally referred to as primary, secondary and control windings. As far as power transformers are concerned, these windings are practically always concentrically arranged and distributed along the length of the core limbs. The core transformer usually has circular coils as well as a tapering core limb section in order to fill up the window as effectively as possible.

In addition to the core type transformer there is so-called shell-type transformer. These are often designed with rectangular coils and a rectangular core limb section.

Conventional power transformers, in the lower end of the above-mentioned power range, are sometimes designed with air cooling to dissipate the heat from inherent losses. For protection against contact, and for possibly reducing the external magnetic field of the transformer, it is often provided with an outer casing provided with ventilation openings.

Most of the conventional power transformers, however, are oil-cooled. One of the reasons for this is that the oil has an additional very important function as insulating medium. An oil-cooled and oil-insulated power transformer is therefore surrounded by an external tank on which, as will be clear from the description below, very high demands are placed.

Usually, means for water-cooling of the oil are provided.

The following part of the description will for the most part refer to oil-filled power transformers.

The windings of the transformer are formed from one or several coils connected in series built up of a number of turns connected in series. In addition, the coils are provided with a special device to allow switching between the taps of the coils. Such a device may be designed for tapping with the aid of screw joints or more often with the aid of a special switch which is operable in the vicinity of the tank. In the event that switching can take place for a transformer under voltage, the changeover switch is referred to as an on-load tap changer whereas otherwise it is referred to as a de-energized tap changer.

Regarding oil-cooled and oil-insulated power transformers in the upper power range, the contacts of the on-load tap changers are placed in special oil-filled containers with direct connection to the transformer tank. The contacts are operated purely mechanically via a motor-driven rotating shaft and are arranged so as to obtain a fast movement during the switching when the contact is open and a slower movement when the contact is to be closed. The on-load tap changers as such, however, are placed in the actual transformer tank. During the operation, arcing and sparking occur. This leads to degradation of the oil in the containers. To obtain less arcs and hence also less formation of soot and less wear on

the contacts, the on-load tap changers are usually connected to the high-voltage side of the transformer. This is due to the fact that the currents which need to be broken and connected, respectively, are smaller on the high-voltage side than if the on-load tap changers were to be connected to the low-voltage side. Failure statistics of conventional oil-filled power transformers show that it is often the on-load tap changers which give rise to faults.

In the lower power range of oil-cooled and oil-insulated power transformers, both the on-load tap changers and their contacts are placed inside the tank. This means that the above-mentioned problems with respect to degradation of the oil because of arcing during operation, etc., affect the whole oil system.

From the point of view of applied or induced voltage, it can broadly be said that a voltage which is stationary across a winding is distributed equally onto each turn of the winding, i.e., the turn voltage is equal on all the turns.

From the point of view of electric potential, however, the situation is completely different. One end of a winding is usually connected to earth. This means, however, that the electric potential of each turn increases linearly from practically zero in the turn which is nearest the earth potential up to a potential in the turns which are at the other end of the winding which correspond to the applied voltage.
This potential distribution determines the composition of the insulation system since it is necessary to have sufficient insulation both between adjacent turns of the winding and between each turn and earth.

The turns in an individual coil are normally brought together into a geometrical coherent unit, physically delimited from the other coils. The distance between the coils is also

determined by the dielectric stress which may be allowed to occur between the coils. This thus means that a certain given insulation distance is also required between the coils. According to the above, sufficient insulation distances are also required to the other electrically conducting objects which are within the electric field from the electric potential locally occurring in the coils.

It is thus clear from the above-mentioned description that for the individual coils, the voltage difference internally between physically adjacent conductor elements is relatively low whereas the voltage difference externally in relation to other metal objects - the other coils being included - may be relatively high. The voltage difference is determined by the voltage induced by magnetic induction as well as by the capacitively distributed voltages which may arise from a connected external electrical system on the external connections of the transformer. The voltage types which may enter externally comprise, in addition to operating voltage, lightning overvoltages and switching overvoltages.

In the current conductors of the coils, additional losses arise as a result of the magnetic leakage field around the conductor. To keep these losses as low as possible, especially for power transformers in the upper power range, the conductors are normally divided into a number of conductor elements, often referred to as strands, which are connected in parallel during operation. These strands must be transposed according to such a pattern that the induced voltage in each strand becomes as equal as possible and so that the difference in induced voltage between each pair of strands becomes as small as possible for internally circulating current components to be kept down at a reasonable level from the loss point of view.

When designing transformers according to the prior art, the general aim is to have as large a quantity of conductor

material as possible within a given area limited by the so-called transformer window, generally described as having as high a fill factor as possible. The available space shall comprise, in addition to the conductor material, also the insulating material associated with the coils, partly internally between the coils and partly to other metallic components including the magnetic core.

The insulation system, partly within a coil/winding and partly between coils/windings and other metal parts, is normally designed as a solid cellulose- or varnish-based insulation nearest the individual conductor element, and outside of this as solid cellulose and liquid, possibly also gaseous, insulation. In this way, windings with insulation and possible support parts represent large volumes which will be subjected to high electric field strengths which arise in and around the active electromagnetic parts of the transformer. In order to predetermine the dielectric stresses which arise and achieve a dimensioning with a minimum risk of breakdown, good knowledge of the properties of insulating materials is required. It is also important to achieve such a surrounding environment that it does not change or reduce the insulating properties.

The currently predominant insulation system for high-voltage power transformers comprises cellulose material as the solid insulation and transformer oil as the liquid insulation. The transformer oil is based on so-called mineral oil.

The transformer oil has a dual function since, in addition to the insulating function, it actively contributes to cooling of the core, the winding, etc., by removal of the loss heat of the transformer. Oil cooling requires an oil pump, an external cooling element, an expansion vessel, etc.

The electrical connection between the external connections of the transformer and the immediately connected coils/windings

is referred to as a bushing aiming at a conductive connection through the wall of the tank which, in the case of oil-filled power transformers, surrounds the actual transformer. The bushing is often a separate component fixed to the tank wall and is designed to withstand the insulation requirements being made, both on the outside and the inside of the tank, while at the same time it should withstand the current loads occurring and the resulting current forces.

It should be pointed out that the same requirements for the insulation system as described above regarding the windings also apply to the necessary internal connections between the coils, between bushings and coils, different types of switches and the bushings as such.

All the metallic components inside a power transformer are normally connected to a given earth potential with the exception of the current-carrying conductors. In this way, the risk of an unwanted, and difficult-to-control, potential increase as a result of capacitive voltage distribution between current leads at high potential and earth is avoided. Such an unwanted potential increase may give rise to partial discharges, so-called corona, which may be revealed during the normal acceptance tests, which partially are performed, compared with rated data, increased voltage and frequency. Corona may give rise to damage during operation.

The individual coils in a transformer must have such a mechanical dimensioning that they may withstand any stresses occurring as a consequence of currents arising and the resulting current forces during a short-circuit process. Normally, the coils are designed in such a way that the forces arising are absorbed within each individual coil, which in turn may mean that the coil cannot be dimensioned optimally for its normal function during normal operation.

Within a narrow voltage and power range of oil-filled power transformers, the windings are designed as so-called helical windings. This implies that the individual conductors mentioned above are replaced by thin sheets. Helical-wound power transformers are manufactured for voltages of up to 20-30 kV and powers of up to 20-30 MW.

The insulation system of power transformers within the upper power range requires, in addition to a relatively complicated design, also special manufacturing measures to utilize the properties of the insulation system in the best possible way. In order to obtain a good insulation to be obtained, the insulation system shall have a low moisture content, the solid part of the insulation shall be well impregnated with the surrounding oil and the risk of remaining "gas" pockets in the solid part must be minimal. To ensure this, a special drying and impregnating process is carried out on a complete core with windings before it is lowered into a tank. After this drying and impregnating process, the transformer is lowered into the tank which is then sealed. Before filling of oil, the tank with the immersed transformer must be emptied of all its air. This is done in connection with a special vacuum treatment. After carrying this out the tank is filled with oil.

In order to obtain the promised service life, etc., almost absolute vacuum is required during the vacuum treatment. This thus presupposes that the tank which surrounds the transformer is designed for full vacuum, which entails a considerable consumption of material and manufacturing time.

If electric discharges occur in an oil-filled power transformer, or if a local considerable increase of the temperature in any part of the transformer occurs, the oil disintegrates and gaseous products dissolve in the oil. The transformers are therefore usually provided with monitoring devices for detection of gas dissolved in the oil.

For weight reasons large power transformers are transported without oil. On-site installation of the transformer at the customer requires, in turn, renewed vacuum treatment. In addition, this is a process which, furthermore, has to be repeated each time the tank is opened for some repair work or inspection.

It is obvious that these processes are very time-consuming and cost-demanding and constitute a considerable part of the total time for manufacture and repair while at the same time requiring access to extensive resources.

The insulating material in conventional power transformers constitutes a large part of the total volume of the transformer. For a power transformer in the upper power range, oil quantities in the order of several tens of cubic metres of transformer oil are not unusual. The oil which exhibits a certain similarity to diesel oil is thinly fluid and exhibits a relatively low flash point. It is thus obvious that oil together with the cellulose constitutes a non-negligible fire hazard in the case of unintentional heating, for example at an internal flashover and a resulting oil spillage.

It is also obvious that, especially in oil-filled power transformers, there is a very large transport problem. Such a power transformer in the upper power range may have a total oil volume of several decades of cubic metres and may have a weight of up to several hundred tons. It is realized that the external design of the transformer must sometimes be adapted to the current transport profile, i.e., for any passage of bridges, tunnels, etc.

A short summary of the prior art with respect to oil-filled power transformers follows hereafter in which both its limitations and problem areas will be described:

An oil-filled conventional power transformer

- comprises an outer tank which is to house a transformer comprising a transformer core with coils, oil for insulation and cooling, mechanical support devices of various kinds, etc. Very large mechanical demands are placed on the tank, since, without oil but with a transformer, it shall be capable of being vacuum-treated to practically full vacuum. The tank requires very extensive manufacturing and testing processes and the large external dimensions of the tank also normally entail considerable transport problems;

- normally comprises a so-called pressure-oil cooling. This cooling method requires the provision of an oil pump, an external cooling element, an expansion vessel and an expansion coupling, etc.;

- comprises an electrical connection between the external connections of the transformer and the immediately connected coils/windings in the form of a bushing fixed to the tank wall. The bushing is designed to withstand any insulation requirements made, both regarding the outside and the inside of the tank;

- comprises coils/windings whose conductors are divided into a number of conductor elements, strands, which have to be transposed in such a way that the voltage induced in each strand becomes as equal as possible and such that the difference in induced voltage between each pair of strands becomes as small as possible;

- comprises an insulation system, partly within a coil/winding and partly between coils/windings and other metal parts which is designed as a solid cellulose- or varnish-based insulation nearest the individual conductor element and, outside of this, solid cellulose and a liquid, possibly also gaseous, insulation. In addition, it is

extremely important that the insulation system exhibits a very low moisture content;

- comprises as an integrated part an on-load tap changer, surrounded by oil and normally connected to the high-voltage winding of the transformer for voltage control;

- comprises oil which may entail a non-negligible fire hazard in connection with internal partial discharges, so-called corona, sparking in on-load tap changers and other fault conditions;

- comprises normally a monitoring device for monitoring gas dissolved in the oil, which occurs in case of electrical discharges therein or in case of local increases of the temperature;

- comprises oil which, in the event of damage or accident, may result in oil spillage leading to extensive environmental damage.

SUMMARY OF THE INVENTION, ADVANTAGES

The object of the invention is to offer a transformer concept within the power range which has been described under the description of the background art, that is, so-called power transformers with a rated power ranging from a few hundred kVA up to over 1000 MVA with a rated voltage ranging from 3-4 kV and up to very high transmission voltages, such as 400 kV to 800 kV or higher, and which does not entail the disadvantages, problems and limitations which are associated with the prior art oil-filled power transformers according to what is clear from the above-mentioned description of the prior art. The invention is based on the realization that, by designing

the winding or the windings in the transformer/reactor so that it comprises a solid insulation surrounded by an outer and an inner potential-equalizing semiconducting layer, within which inner layer the electric conductor is located, a possibility is provided of maintaining the electric field in the whole plant within the winding. The electric conductor must, according to the invention, be so arranged that it has such a conducting contact with the inner semiconducting layer that no harmful potential differences may arise in the boundary layer between the innermost part of the solid insulation and the surrounding inner semiconductor along the length of the conductor. A power transformer according to the invention exhibits obvious considerable advantages in relation to a conventional oil-filled power transformer. The advantages will be described in more detail below. As mentioned in the introductory part of the description, the invention also provides for the concept to be applied to reactors both with and without an iron core.

The essential difference between conventional oil-filled power transformers/reactors and a power transformer/reactor according to the invention is that the winding/windings thus comprise a solid insulation surrounded by an external and an internal potential layer as well as at least one electric conductor arranged inside the internal potential layer, designed as semiconductors. A definition of what is comprised by the concept semiconductor will be described below. According to a preferred embodiment, the winding/windings is/are designed in the form of a flexible cable.

At the high voltage levels which are required in a power transformer/reactor according to the invention, which is connected to high-voltage networks with very high operating voltages, the electric and thermal loads which may arise will impose extreme demands on the insulating material. It is known that so-called partial discharges, PD, generally constitute a serious problem for the insulating material in

high-voltage installations. If cavities, pores or the like arise at an insulating layer, internal corona discharge may arise at high electric voltages, whereby the insulating material is gradually degraded and which finally may lead to electric breakdown through the insulation. It is realized that this may lead to serious breakdown of, for example, a power transformer.

The invention is, inter alia, based on the realization that the semiconducting potential layers exhibit similar thermal properties as regards the coefficient of thermal expansion and that the layers are secured to the solid insulation. Preferably, the semiconducting layers according to the invention are integrated with the solid insulation to ensure that these layers and the adjoining insulation exhibit similar thermal properties to ensure good contact independently of the variations in temperature which arise in the line at different loads. At temperature gradients the insulating part with semiconducting layers will constitute a monolithic part and defects caused by different temperature expansion in the insulation and the surrounding layers do not arise. The electric load on the material is reduced as a consequence of the fact that the semiconducting parts around the insulation will constitute equipotential surfaces and that the electric field in the insulating part will hence be distributed nearly uniformly over the thickness of the insulation.

According to the invention, it must be ensured that the insulation is not broken down by the phenomena described above. This can be achieved by using as insulation layers, manufactured in such a way that the risk of cavities and pores is minimal, for example extruded layers of a suitable thermoplastic material, such as crosslinked PE (polyethylene), XLPE and EPR (ethylene-propylene rubber). The insulating material is thus a low-loss material with high

breakdown strength, which exhibits shrinkage when being loaded.

The electric load on the material is reduced as a consequence of the fact that the semiconducting parts around the insulation will constitute equipotential surfaces and that the electric field in the insulating part will hence be distributed nearly uniformly over the thickness of the insulation.

It is known, per se, in connection with transmission cables for high-voltage and for transmission of electric energy, to design conductors with an extruded insulation, based on the premise that the insulation should be free from defects. In these transmission cables, the potential lies, in principle, at the same level along the whole length of the cable, which provides a high electric stress in the insulating material. The transmission cable is provided with one inner and one outer semiconducting layer for potential equalization.

The present invention is thus based on the realization that, by designing the winding according to the characteristic features described in the claims as regards the solid insulation and the surrounding potential-equalizing layers, a transformer/reactor can be obtained in which the electric field is kept within the winding. Additional improvements may also be achieved by constructing the conductor from smaller insulated parts, so-called strands. By making these strands small and circular, the magnetic field across the strands will exhibit a constant geometry in relation to the field and the occurrence of eddy currents will be minimized.

According to the invention, the winding/windings is/are thus preferably made in the form of a cable comprising at least one conductor comprising a number of strands and with an inner semiconducting layer around the strands. Outside of this inner semiconducting layer is the main insulation of the cable in the form of a solid insulation, and around this

solid insulation is an outer semiconducting layer. The cable may in certain contexts have additional outer layers.

According to the invention, the outer semiconducting layer shall exhibit such electrical properties that a potential equalization along the conductor is ensured. The semconducting layer must not, however, exhibit such conductivity properties that the induced current causes an unwanted thermal load. Further, the conductor properties of the layer must be sufficient to ensure that an equipotential surface is obtained. The resistivity, ρ, of the semiconducting layer shall exhibit a minimum value, ρ_{min} = 1 Ωcm, and a maximum value, ρ_{max} = 100 kΩcm, and, in addition, the resistance of the semiconducting layer per unit of length in the axial extent, R, of the cable shall exhibit a minimum value R_{min} = 50 Ω/m and a maximum value R_{max} = 50 MΩ/m.

The inner semiconducting layer must exhibit sufficient electrical conductivity in order for it to function in a potential-equalizing manner and hence equalizing with respect to the electric field outside the inner layer. In this connection it is important that the layer has such properties that it equalizes any irregularities in the surface of the conductor and that it forms an equipotential surface with a high surface finish at the boundary layer with the solid insulation. The layer may, as such, be formed with a varying thickness but to ensure an even surface with respect to the conductor and the solid insulation, its thickness is suitably between 0.5 and 1 mm. However, the layer must not exhibit such a great conductivity that it contributes to induce voltages. For the inner semiconducting layer, thus, ρ_{min} = 10^{-6} Ωcm, R_{min} = 50 $\mu\Omega$/m and, in a corresponding way, ρ_{max} = 100 kΩcm, R_{max} = 5 MΩ/m.

Such a cable which is used according to the invention is an improvement of a thermoplastic cable and/or a cross linked thermoplastic such as XLPE or a cable with ethylene propylene

(EP) rubber insulation or other rubber, for example silicone. The improvement comprises, inter alia, a new design both as regards the strands of the conductors and in that the cable has no outer casing for mechanical protection of the cable.

A winding comprising such a cable will entail quite different conditions from the insulation point of view from those which apply to conventional transformers/reactor windings due to the electric field distribution. To utilize the advantages afforded by the use of the mentioned cable, there are other possible embodiments as regards earthing of a transformer/reactor according to the invention than what apply to conventional oil-filled power transformers.

It is essential and necessary for a winding in a power transformer/reactor according to the invention that at least one of the strands of the conductor is uninsulated and arranged such that good electrical contact is achieved with the inner semiconducting layer. The inner layer will thus always remain at the potential of the conductor. Alternatively, different strands may be alternately conducting with electrical contact with the inner semiconducting layer.

As far as the rest of the strands are concerned, all of them or some of them may be varnished and hence insulated.

According to the invention the terminations of the high-voltage and low-voltage windings can either be of joint type (when the connection is to a cable system) or of cable termination type (when the connection is to a switchgear or to an overhead transmission line). These parts also consist of solid insulation material, thus fulfilling the same PD demands as the whole insulation system.

According to the invention the transformer/reactor can either have external or internal cooling, external meaning gas or

liquid cooling on earth potential and internal meaning gas or liquid cooling inside the winding.

Manufacturing transformer or reactor windings of a cable according to the above, entails drastic differences as regards the electric field distribution between conventional power transformers/reactors and a power transformer/reactor according to the invention. The decisive advantage with a cable-formed winding according to the invention is that the electric field is enclosed in the winding and that there is thus no electric field outside the outer semiconducting layer. The electric field from the current-carrying conductor is present only in the solid main insulation. Both from the design point of view and the manufacturing point of view this has considerable advantages:

- the windings of the transformer may be formed without having to consider any electric field distribution and the transposition of strands, mentioned under the background art, is omitted;

- the core design of the transformer may be formed without having to consider any electric field distribution;

- no oil is needed for electrical insulation of the winding, i.e., the medium surrounding the winding may be air;

- no oil is needed for cooling of the winding. The cooling can be performed on ground potential and as cooling medium a gas or a liquid can be used;

- no special connections are required for electrical connection between the outer connections of the transformer and the immediately connected coils/windings, since the electrical connection, contrary to conventional plants, is integrated with the winding;

- traditional transformer/reactor bushings are not necessary. Instead, field conversion from radial to axial field outside the transformer/reactor can be realized similar as for a traditional cable termination;

- the manufacturing and testing technology which is needed for a power transformer according to the invention is considerably simpler than for a conventional power transformer/reactor since the impregnation, drying and vacuum treatments described under the description of the background art are not needed. This provides considerably shorter production times;

- by using the technique for insulation, according to the invention, considerable possibilities are provided for developing the magnetic circuit of the transformer, which was given according to the prior art.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention will now be described with reference to the accompanying drawings, wherein

Figure 1 shows the electric field distribution around a winding of a conventional power transformer/reactor,

Figure 2 shows an embodiment of a winding in the form of a cable in power transformers/reactors according to the invention, and

Figure 3 shows an embodiment of a power transformer according to the invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Figure 1 shows a simplified and fundamental view of the electric field distribution around a winding of a conventional

power transformer/reactor, where 1 is a winding and 2 a core and 3 illustrates equipotential lines, i.e., lines where the electric field has the same magnitude. The lower part of the winding is assumed to be at earth potential.

The potential distribution determines the composition of the insulation system since it is necessary to have sufficient insulation both between adjacent turns of the winding and between each turn and earth. The figure thus shows that the upper part of the winding is subjected to the highest dielectric stress. The design and location of a winding relative to the core are in this way determined substantially by the electric field distribution in the core window.

Figure 2 shows an example of a cable which may be used in the windings which are included in power transformers/reactors according to the invention. Such a cable comprises at least one conductor 4 consisting of a number of strands 5 with an inner semiconducting layer 6 disposed around the strands. Outside of this inner semiconducting layer is the main insulation 7 of the cable in the form of a solid insulation, and surrounding this solid insulation is an outer semiconducting layer 8. As previously mentioned, the cable may be provided with other additional layers for special purposes, for example for preventing too high electric stresses on other regions of the transformer/reactor. From the point of view of geometrical dimension, the cables in question will have a conductor area which is between 30 and 3000 mm^2 and an outer cable diameter which is between 20 and 250 mm.

The windings of a power transformer/reactor manufactured from the cable described under the summary of the invention may be used both for single-phase, three-phase and polyphase transformers/reactors independently of how the core is shaped. One embodiment is shown in Figure 3 which shows a three-phase laminated core transformer. The core comprises, in conventional manner, three core limbs 9, 10 and 11 and the

retaining yokes 12 and 13. In the embodiment shown, both the core limbs and the yokes have a tapering cross section.

Concentrically around the core limbs, the windings formed with the cable are located. As is clear, the embodiment shown in Figure 3 has three concentric winding turns 14, 15 and 16. The innermost winding turn 14 may represent the primary winding and the other two winding turns 15 and 16 may represent secondary windings. In order not to overload the figure with too many details, the connections of the windings are not shown. Otherwise the figure shows that, in the embodiment shown, spacing bars 17 and 18 with several different functions are located at certain points around the windings. The spacing bars may be formed of insulating material intended to provide a certain space between the concentric winding turns for cooling, supporting, etc. They may also be formed of electrically conducting material in order to form part of the earthing system of the windings.

CLAIMS

1. A power transformer/reactor comprising at least one winding, **characterized** in that the winding/windings comprise one or more current-carrying conductor, that around each conductor (4) there is arranged a first layer (6) with semiconducting properties, that around the first layer there is arranged a solid insulating part (7), and that around the insulating part there is arranged a second layer (8) with semiconducting properties.

2. A power transformer/reactor according to claim 1, **characterized** in that the first layer (6) is at substantially the same potential as the conductor.

3. A power transformer/reactor according to one or more of the preceding claims, **characterized** in that the second layer (8) is arranged in such a way that it essentially constitutes an equipotential surface surrounding the conductor/conductors.

4. A power transformer/reactor according to one or more of the preceding claims, **characterized** in that the second layer (8) is connected to earth potential.

5. A power transformer/reactor according to one or more of the preceding claims, **characterized** in that the semiconducting layers (6,8) and the insulating part (7) have substantially the same coefficient of thermal expansion such that, upon a thermal movement in the winding, defects, cracks or the like do not arise in the boundary layer between the semiconducting layers and the insulating part.

6. A power transformer/reactor according to one or more of the preceding claims, **characterized** in that each of the semiconducting layer (6,8) is secured to the adjacent solid

insulating part (7) along essentially the whole adjoining surface.

7. A power transformer/reactor according to one or more of the preceding claims, **characterized** in that the winding/windings is/are designed in the form of a flexible cable.

8. A power transformer/reactor according to claim 7, **characterized** in that the cable is manufactured with a conductor area which is between 30 and 3000 mm^2 and with an outer cable diameter which is between 20 and 250 mm.

9. A power transformer/reactor according to one or more of the preceding claims, **characterized** in that the solid insulation (7) are formed by polymeric materials.

10. A power transformer/reactor according to one or more of the preceding claims, **characterized** in that the first layer (6) and/or the second layer (8) are formed by polymeric materials.

11. A power transformer/reactor according to one or more of the preceding claims, **characterized** in that the solid insulation (7) has been obtained by extrusion.

12. A power transformer/reactor according to one or more of the preceding claims, **characterized** in that the current-carrying conductor (4) comprises a number of strands, said strands being insulated from each other except a few strands that are uninsulated in order to secure electric contact with the first semiconducting layer (6).

13. A power transformer/reactor according to one or more of the preceding claims, **characterized** in that at least one of the strands of the conductor (4) is uninsulated and arranged

in such a way that electrical contact is achieved with the inner semiconducting layer.

14. A power transformer/reactor according to one or more of the preceding claims, **characterized** in that the power transformer/reactor comprises a core consisting of magnetic material.

15. A power transformer/reactor according to one or more of the preceding claims, **characterized** in that the power transformer/reactor comprises an iron core consisting of core limbs and yokes.

16. A power transformer/reactor according to claim 1-13, **characterized** in that the power transformer/reactor is formed without an iron core (air-wound).

17. A power transformer/reactor comprising at least two galvanically separated windings according to any preceding claim, **characterized** in that the windings are concentrically wound.

18. A power transformer/reactor according to one or more of the preceding claims, **characterized** in that the power transformer/reactor is connected to two or more voltage levels.

19. A power transformer/reactor according to one or more of the preceding claims, **characterized** in that the terminals of the high and/or low-voltage winding are jointed to a power cable and/or made similar to power cable termination(s).

20. A power transformer/reactor according to one or more of the preceding claims, **characterized** in that substantially all of the electrical insulation in the transformer/reactor is enclosed between the conductor (4) the second layer (8) of

the windings and which insulation is in the form of solid insulation.

21. A power transformer/reactor according to one or more of the preceding claims, **characterized** in that the winding thereof is designed for high voltage, suitably in excess of 10 kV, in particular in excess of 36 kV, and preferably more than 72,5 kV and up to very high transmission voltages, such as 400 kV to 800 kV or higher.

22. A power transformer/reactor according to one or more of the preceding claims, **characterized** in the transformer/reactor is designed for a power range in excess of 0.5 MVA, preferably in excess of 30 MVA.

23. The cooling of a power transformer/reactor according to one or more of the preceding claims, **characterized** in that the power transformer/reactor is cooled with liquid and/or gas on earth potential.

24. A method for electric field control in a power transformer/reactor comprising a magnetic field generating circuit having at least one winding with at least one electrical conductor and an insulation present externally thereof, **characterized** in that the insulation is formed by a solid insulation material and that an outer layer is provided externally of the insulation, said outer layer being connected to ground or otherwise a relatively low potential and having an electrical conductivity being higher than the conductivity of the insulation but lower than the conductivity of the electrical conductor so as to function for equalization of potential and cause the electrical field to be substantially enclosed in the winding internally of the outer layer

25. A method in production of a power transformer/reactor according to one ore more of the preceding claims,

characterized in that a flexible cable is used as a winding and that the winding of the cable to form the winding/windings of the transformer/reactor is assembled on-site.

ABSTRACT

The present invention relates to a power transformer/reactor (14, 15, 16) for high voltages, comprising at least one winding having at least one current-carrying conductor. The winding comprises a solid insulation (7) surrounded by outer and inner layers (8,6) serving for equalization of potential and having semiconducting properties. The layers (6,8) and the insulation (7) adhere along essentially the whole of its contact surfaces. Said conductor is arranged interiorly of the inner semiconducting layer (6). The outer layer (8) is connected to ground or otherwise relatively low potential. Said solid insulation in the windings constitute substantially the total electrical insulation in the power transformer/reactor.

(Fig. 3)

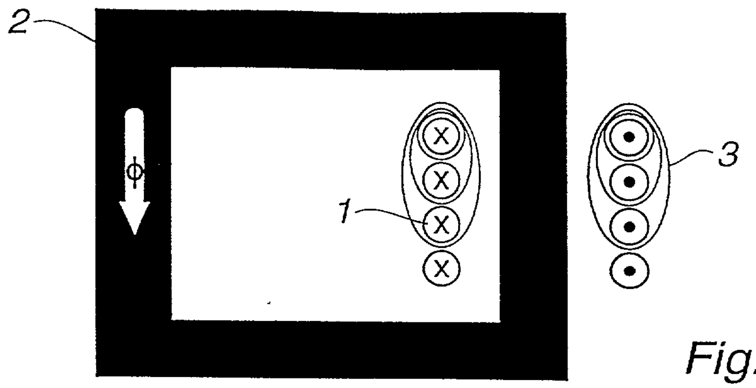

Fig. 1

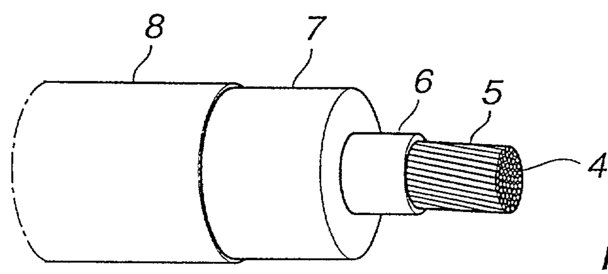

Fig. 2

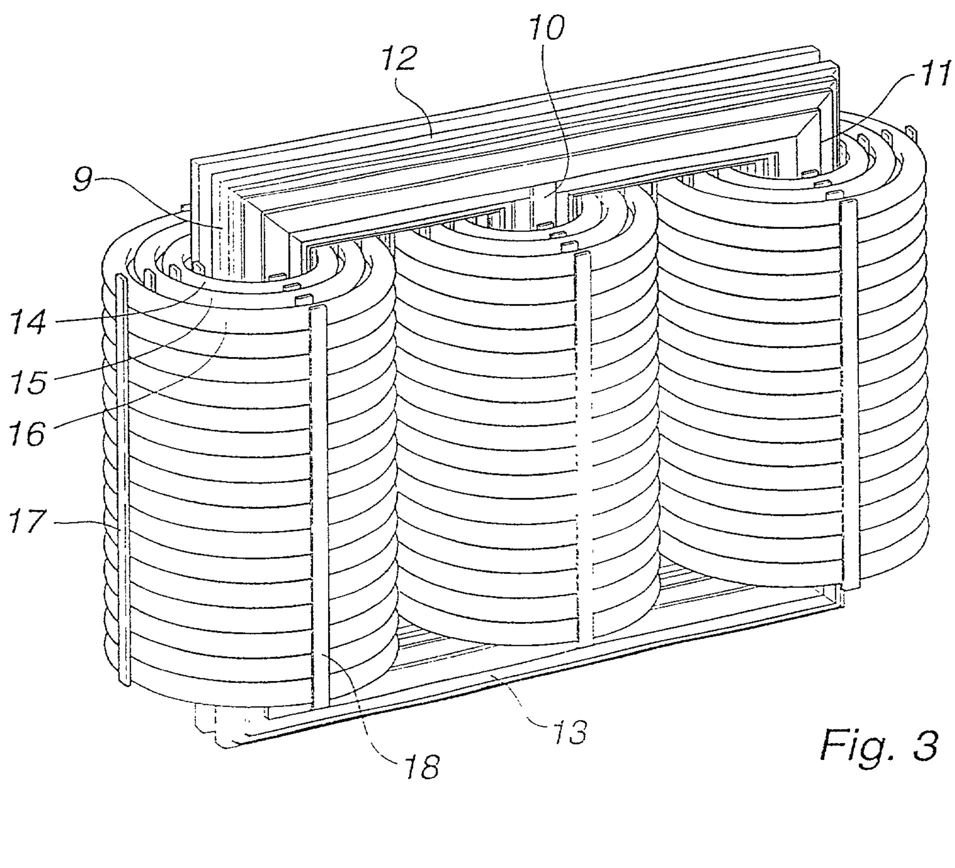

Fig. 3

COMBINED DECLARATION AND POWER OF ATTORNEY FOR UTILITY PATENT APPLICATION (Includes PCT)	Attorney Docket No. 70554-2/8137

As a below named inventor, I hereby declare that:

My residence, post office address and citizenship are as stated below next to my name; that

I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural inventors are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled:

TRANSFORMER/REACTOR

the specification of which (check one)

[ ] is attached hereto.

[ ] was filed on ______________ as Application Serial No. __________.

[X] was filed as PCT international application no. SE97/00875 on 27 May 1997, and was amended under PCT Article 19 on ______________ (if applicable).

I hereby state that I have reviewed and understand the contents of the above identified specification, including the claims, as amended by any amendment referred to above.

I acknowledge the duty to disclose information which is material to the examination of this application in accordance with Title 37, Code of Federal Regulations, §1.56(a).

I do not know and do not believe the claimed invention was ever known or used in the United States of America before my or our invention thereof, or patented or described in any printed publication in any country before my or our invention thereof or more than one year prior to this application, that the same was not in public use or on sale in the United States of America more than one year prior to this application, that the invention has not been patented or made the subject of an inventor's certificate issued before the date of this application in any country foreign to the United States of America on an application filed by me or my legal representatives or assigns more than twelve months prior to this application.

I hereby claim priority benefits under Title 35, United States Code §119 of any application(s) for patent or inventor's certificate listed below and have also identified below any application for patent or inventor's certificate having a filing date before that of the application(s) on which priority is claimed:

Prior Application(s) | Priority Claimed

(Number)	(Country)	Day/Month/Year Filed	Yes	No
9602079-7	Sweden	29 May 1996	[x]	[ ]
9700335-4	Sweden	03 February 1997	[x]	[ ]

I hereby claim the benefit under Title 35, United States Code, §120 of any United States application(s) or PCT international application(s) designating the United States of

Attorney Docket No.
70554-2/8137

America listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in the prior application(s) in the manner provided by the first paragraph of Title 35, United States Code, §112, I acknowledge the duty to disclose material information as defined in Title 37, Code of Federal Regulations, §1.56(a) which occurred between the filing date of the prior application and the national or PCT international filing date of this application:

Application Serial No.	Filing Date	Status (patented, pending, abandoned)
Application Serial No.	Filing Date	Status (patented, pending, abandoned)

I hereby appoint the following attorney(s) and/or agent(s) to prosecute this application and to transact all business in the Patent and Trademark Office connected therewith; Robert J. Lasker, Reg. No. 22,785; Lawrence R. Radanovic, Reg. No. 23,077; Richard H. Tushin, Reg. No. 27,297; Donald N. Huff, Reg. No. 27,561; and John P. DeLuca, Reg. No. 25,505. Direct all telephone calls to telephone no. (202) 628-0088 and faxes to (202) 628-8034.

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I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true, and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity o the application or any patent issued thereon.

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